

Editorial

Special Issue on “Phytochemicals: Extraction, Optimization, Identification, Biological Activities, and Applications in the Food, Nutraceutical, and Pharmaceutical Industries”

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There is growing interest in using natural plant extracts in foods and beverages due to their ability to enhance the quality of food and provide therapeutic benefits [1,2]. Phytochemicals (organic compounds derived from plants) offer significant health-promoting properties beyond their fiber, vitamin, and mineral content [3]. These compounds, known for their antioxidant, antiviral, anticancer, and anti-inflammatory effects, play a vital role in disease prevention and health maintenance [4]. Owing to their diverse properties, they have found many applications in medicine, agriculture, and industry, particularly in the food, pharmaceutical, and nutraceutical sectors [5].

This Special Issue, “Phytochemicals: Extraction, Optimization, Identification, Biological Activities, and Applications in the Food, Nutraceutical, and Pharmaceutical Industries”, focuses on recent advancements in the extraction of phytochemicals and explores their chemical compositions and biological activities. It highlights new analytical and bio-analytical techniques for studying these compounds and their mechanisms of action. It features twelve research papers and three reviews, covering topics such as novel extraction methods, phytochemical bioactivities, and the design of new functional foods and nutraceuticals. These studies underscore the increasing demand for natural bioactive compounds and eco-friendly processing methods, rendering this Special Issue a significant resource for professionals and researchers.

The included studies demonstrate a range of promising applications. For example, Tinh et al. [6] studied fucosylated chondroitin sulfate from *Bohadschia ocellata* and revealed its strong anticoagulant, anticancer, and PTP1B inhibitory activities, suggestive of its therapeutic potential. Moreover, Ramírez-Sucre et al. [7] developed an environmentally friendly method for extracting polyphenols from citrus peel using NADESs and ultrasound, emphasizing its potential for producing a high yield of functional foods and nutraceuticals. By combining green chemistry principles with innovative techniques, the study offers a sustainable approach to maximizing the recovery of bioactive compounds and reducing environmental impact in the food and nutraceutical industries.

A group of researchers optimized the extraction of essential oil from *Lippia graveolens* using ultrasound-assisted deep eutectic solvents, highlighting its potential as an eco-friendly antifungal agent for agriculture. Raucher et al. explored the antiproliferative effects of fruit juices on glioblastoma, finding cornelian cherry and wild blackberry juices more effective than standard chemotherapeutics, substantiating the therapeutic potential of dietary bioactives in cancer treatment. In addition, Carezzano et al. [8] evaluated essential oils and plant extracts as biopesticides against the soybean mosaic virus, offering sustainable alternatives to chemical pesticides. Their research supports environmentally



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friendly agricultural practices and highlights the potential use of botanical extracts in integrated pest management for safer, more sustainable crop protection [9].

Other studies in this Special Issue investigate the optimization of extraction methodologies and the pharmacological relevance of phytochemicals. Hihat et al. [10] explored the microwave-assisted extraction of total phenolic content from *Coriandrum sativum* leaves, presenting a model for optimizing antioxidant yield. This study demonstrates how process optimization can significantly enhance the efficiency of bioactive compound extraction, making it more viable for large-scale applications. Another significant study on *Achyranthes bidentata* aimed to enhance traditional salt-processing techniques to boost its bioactive properties and anti-osteoarthritis effects. This study combined traditional medicine with modern science, validating the use of ancient remedies through contemporary techniques and highlighting their relevance in current healthcare practices.

Jamous et al. [11] developed solid lipid nanoparticles for troxerutin to improve its bioavailability and controlled release, thus enhancing its therapeutic potential. This study demonstrated the vital role of nanotechnology in overcoming challenges in phytochemical delivery, ensuring stability and efficacy and expanding pharmaceutical applications. Other researchers have investigated the antimicrobial activity and bioactive components of *Chamaecyparis obtusa* essential oil. Key compounds, thujopsene and pinene, were identified through GC-MS, and commercial disinfectants containing the oil effectively reduced airborne microorganisms, highlighting its potential as a natural, eco-friendly indoor air disinfectant.

In a study conducted by Manjarrez-Quintero et al. [12], the extraction of essential oil from *Lippia graveolens* biomass was optimized using an ultrasound-assisted deep eutectic solvent method, enhancing its yield and bioactivity. This study underscored its potential as a natural antifungal agent for agricultural use, providing an eco-friendly alternative to synthetic pesticides. Additionally, Raucher and others [13] explored the antiproliferative effects of fruit juices against glioblastoma, revealing the potent effects of cornelian cherry and wild blackberry juice, which exhibited greater efficacy than standard chemotherapeutic agents in glioblastoma cell models. Their findings reinforce the therapeutic value of dietary bioactives and suggest a promising avenue for complementary cancer therapies.

Moreover, Belaiba et al. [14] studied *Ammoides pusilla*, identifying 20 key compounds, including perilic aldehyde and β -phellandrene. Extracts of the plant showed strong antioxidant, anti-diabetic, anti-inflammatory, and anticancer activities and demonstrated significant cytotoxicity against cancer cells, highlighting its therapeutic potential. This study underscores the potential of *A. pusilla* in facilitating drug discovery. The authors of another study highlighted the bioactive compounds present in *Citrus aurantium*, including flavonoids, essential oils, and vitamin C, with antioxidant, antimicrobial, and anti-inflammatory properties. They reviewed eco-friendly extraction methods, such as ultrasound-assisted techniques, to enhance the recovery of synephrine, emphasizing the plant's promising applications in food, pharmaceuticals, and cosmetics and promoting sustainable extraction technologies.

Grabska-Zielińska et al. [15] explored polymer films enhanced with olive leaf extract (OLE) for food packaging and other applications. OLE's antibacterial, antifungal, and antioxidant properties improved the films' functionality and structural integrity, emphasizing its potential application in sustainable food packaging, biomedicine, cosmetics, and future industrial research. Another study assessed the use of *Cnidioscolus quercifolius*, a versatile plant valued for its ecological and medicinal roles in Brazil's Caatinga biome. It exhibits antinociceptive, antioxidant, and anti-inflammatory properties, with applications in treating inflammation and infections. Its seed oil also shows promise for food consumption. The authors called for further research into its bioactive compounds and pharmacological mechanisms to support drug development.

Collectively, the papers in this Special Issue underscore the vast potential of phytochemicals across various applications, from medicine and agriculture to food science and biotechnology. The studies presented enhance our understanding of plant bioactives and their multifunctional roles and stress the need for environmentally friendly extraction and optimization processes. By integrating scientific advancements with practical applications, these studies pave the way for innovative solutions that address critical global challenges, from disease prevention to sustainable resource utilization.

We extend our thanks to the authors, reviewers, and editorial team for their important contributions to this Special Issue. This collection will serve as a significant resource for researchers, practitioners, and policymakers, inspiring further advancements and fostering innovation in phytochemistry and related fields. The continued exploration of phytochemicals will undoubtedly lead to new discoveries that benefit both human health and the environment, reinforcing the indispensable role of natural compounds in scientific progress.

Conflicts of Interest: The author declares no conflict of interest.

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